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# The Hydrozoan *Cladonema* in California: A Possible Introduction from East Asia[1]

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ABSTRACT: A hydrozoan of the genus *Cladonema*, new to the American west coast, is described from specimens taken from a display tank on the Berkeley campus of the University of California. Observations of its life history revealed it to be synonymous with *Cladonema uchidai* Hirai, 1958, known and described from northern Japan, although its distribution is probably much wider and includes coastal China and the USSR. The species is presumed to be present in San Francisco Bay, a point of introduction for many exotic species, although it is not yet known from the field.

THE HYDROZOAN *Cladonema* is characterized by benthic medusae capable of adhering to substrata with specialized adhesive tentacles. The hydroid colony is generally reptant and inconspicuous, and the minute polyps at maturity have a whorl of 4 capitate tentacles surrounding the mouth.

The systematics of the genus have been reviewed by the present author (J. T. Rees 1979*b*). *Cladonema radiatum* Dujardin, 1843, and its varieties have been reported from the eastern Atlantic, Bermuda, and the Mediterranean (Kramp 1961). The medusa of *Cladonema californicum* Hyman, 1947, with its characteristic bifurcated regular tentacles, has been reported from scattered locations along the west coast of North America from Monterey Bay, California, to British Columbia (Arai and Brinckmann-Voss 1980). *Cladonema myersi*, known only from southern California, which has a mature medusa very similar in morphology to that of *C. radiatum*, differs from the latter in the lack of filiform tentacles at the base of the polyp (W. J. Rees 1949). The medusa of *Cladonema uchidai*, described from Asamushi in North Honshu, Japan, is indistinguishable from the medusa of *C. radiatum*, but lacks filiform tentacles at the base of the polyp characteristic of the latter species (Hirai 1958).

Twice within the past two years jellyfish of the genus *Cladonema* have come to my attention that do not agree with the description of either species known to occur on the coast of California, namely, *C. californicum* and *C. myersi*. After examining these medusae and other live material which subsequently became available, I concluded that a third species of *Cladonema*, probably *C. uchidai*, is present in central California, and I suspect that it was introduced from East Asia.

## MATERIALS AND METHODS

In 1979 Daphne Dunn of the California Academy of Sciences brought to my attention 25 or so medusae found in a home aquarium in the San Francisco Bay area, presumably from San Francisco. She did not know the source of the material, no date was given, and the specimens were tentatively identified as *Cladonema radiatum*. On 26 January 1981, Ralph Smith of the Zoology Department of the University of California, Berkeley, found two *Cladonema* medusae of similar morphology attached to the wall of a display aquarium on the Berkeley campus. There was a variety of fouling fauna in the tanks which Smith averred came only from one of two sources: (1) dock floats of the Berkeley marina, located on the east side of San Francisco Bay across from the Golden Gate, or (2) similar floats from Bodega harbor, a small, shallow bay in Sonoma County about

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60 km north of San Francisco, near the Bodega Marine Laboratory of the University of California. Smith began introducing *Artemia* nauplii into the original tank and a second adjacent tank on a regular basis as a food source for the medusae and the polyps of the hydroid colonies. The colonies were visibly growing on the glass sides of the tanks adjacent to the gravel bottom. Both the polyps and medusae had fared well on an indigenous supply of benthic copepods, which were visible in abundance on the glass walls of the tanks. The introduction of *Artemia* resulted in more vigorous hydroid colony growth and the release of larger numbers of medusae. Both polyps and medusae in all stages of development were observed and photographed live, and material was preserved for future reference. Polyps were also maintained for further observation in the laboratory in petri dishes for a period of two weeks. The polyps were obtained by collecting sand grains from the bottom of the display tanks. Polyps were observed to feed on *Artemia* nauplii. Medusae were more fragile and could only be maintained for about 48 hours. Cnidae were examined and measured from specimen squashes of live polyps and medusae.

## RESULTS

Figure 1*a–h* documents the life history and growth stages of the *Cladonema* found in the display tanks on the Berkeley campus. Polyps were observed to form creeping, non-branching colonies on the sides of the tanks. Polyps were minute, about 0.5 mm in height, and possessed four capitate tentacles surrounding the hypostome (Figure 1*a*). Polyps observed adhering to sand grains collected from the display tanks lacked filiform tentacles. The smallest medusae observed were about 1 mm in bell height (Figure 1*b*). Medusae observed at this developmental stage had the full complement of nine radial canals, and each tentacle bulb had one adhesive and one regular tentacle. In medusae 2 mm in height, considerable tentacle development had become evident (Figure 1*c*, *d*). The tentacle bulbs had enlarged and lengthened, and up to five tentacles in various stages of development were present. Development of the tentacles was seen to proceed in a definite order. The oldest and largest tentacles, those most distal from the tentacle bulb, were regular tentacles with scattered nematocyst batteries clearly evident. Those most proximal to the tentacle bulb and most recently formed were adhesive tentacles. Those tentacles in between were in varying stages of development. Therefore tentacles underwent a change in development from adherent tentacles, with their large terminal adhesive pad, to regular tentacles as medusae developed and matured. In medusae over 2 mm in height a slight peduncle began to form above the manubrium, which hung almost to the velar opening. The largest medusae observed were 3.5 mm in bell height, and male gonadal tissue was observed in specimens of this size (Figure 1*e–g*). There were up to seven tentacles on each tentacle bulb, the most proximal two to three of which were adhesive tentacles. The more distal four to five of which were regular tentacles. The bell was wider than it was high, and a peduncle was present. There were nine radial canals in all the specimens studied, the canals issuing from the top of the stomach in a characteristic branching pattern in which alternating canals arose in pairs (Figure 1*h*).

The cnidom of the *Cladonema* from the display tanks on the Berkeley campus is given in Table 1. Types of nematocysts, stenoteles, and desmonemes are the same as those found in *C. californicum*, but sizes and distribution differ somewhat between the two (J. T. Rees 1979*b*). Desmonemes were not seen in the 1 mm size medusae examined from the Berkeley campus but are present in *C. californicum* medusae of a similar size. There is a second smaller size of stenotele present in the Berkeley specimens which is not present in *C. californicum*. Such differences between cnidae of species in the same hydrozoan genus are minor and are to be expected.

## DISCUSSION

The morphology of the polyp and medusa of the *Cladonema* occurring in the San Fran-

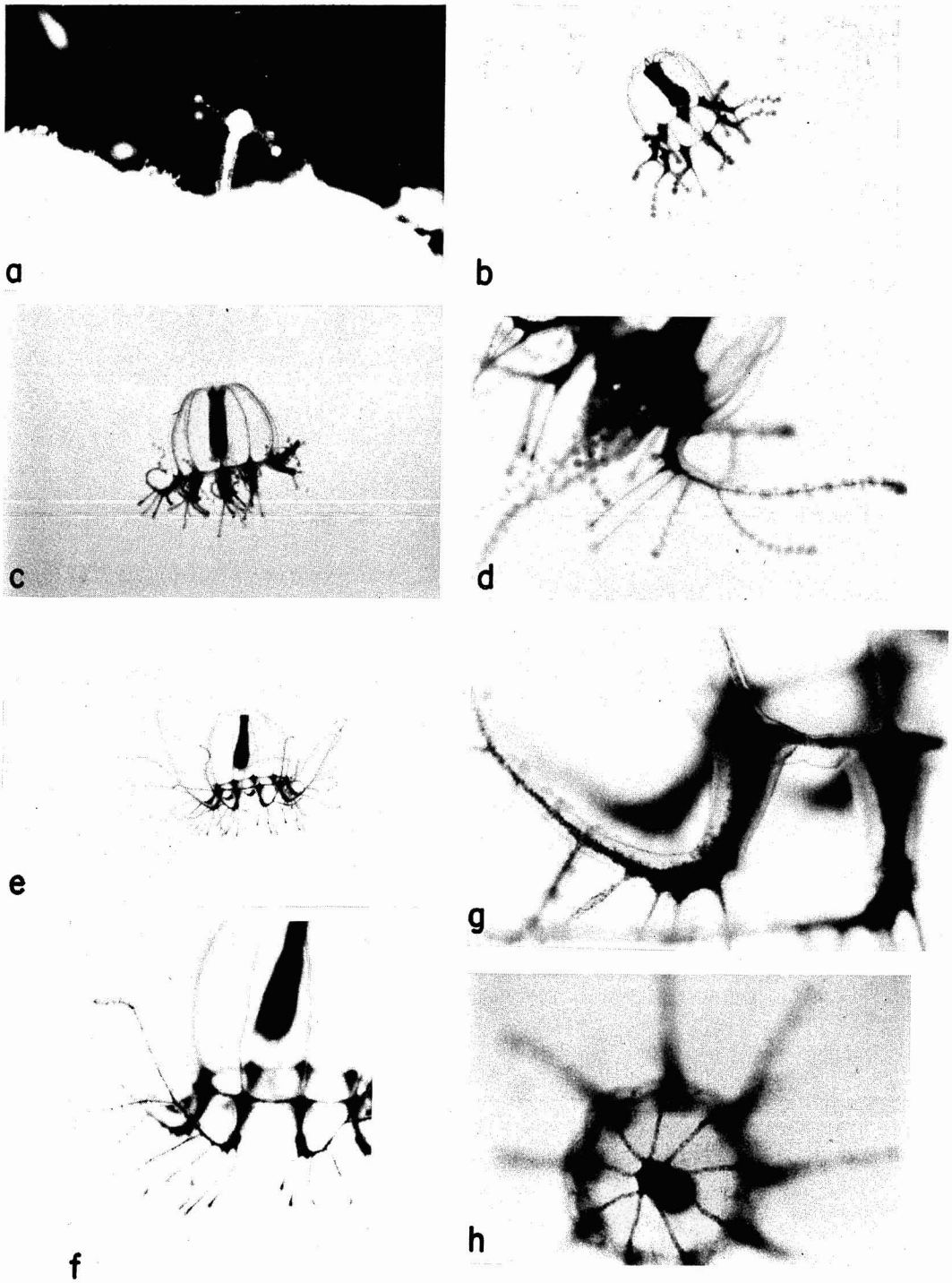


FIGURE 1. Selected growth stages and morphological features of the Berkeley *Cladonema*: (*a*) polyp, height 0.5 mm; (*b*) newly released medusa, bell height 1 mm; (*c*) medusa, 2 mm bell height; (*d*) tentacle detail of medusa, 2 mm bell height; (*e*) mature medusa, 3.5 mm bell height; (*f*) tentacle detail of same; (*g*) tentacle bulb showing proximal tentacle bulb and ocellus of medusa, 3.5 mm bell height; (*h*) top view of bell of medusa, 2.5 mm bell height.

TABLE 1

MEASUREMENTS OF CNIDOM OF THE *Cladonema* FROM THE BERKELEY CAMPUS*

| | MEDUSA | |
|---|---|---|
| POLYP (μm) | 1 MM BELL HEIGHT (μm) | 2.5 MM BELL HEIGHT (μm) |
| Stenoteles | | |
| Size I 11.5–12 × 16.5–20 | 10–11.5 × 15.5–16 | 13.5–14 × 20.5–23 |
| Size II 8 × 13–14 | 7–9 × 10–14 | 7–8 × 11.5–14 |
| Desmonemes | | |
| None present | None seen | 4 × 9–10 |

*One specimen of each category examined.

cisco Bay area does not fit the description of either species known to occur on the west coast of North America (Table 2). The polyp does not possess filiform tentacles as does *C. californicum*, and the morphology of the adult medusa is quite different, the adult possessing multiple regular tentacles unlike the characteristic two regular tentacles of *C. californicum*. While the polyp of *C. myersi* is similar to the Bay Area *Cladonema* in its lack of filiform tentacles, the adult medusa is different, notably in the smaller number of radial canals (5 to 7 vs. 9), and in the apparent lack of alternate dichotomous branching of the radial canals at the origin at the apex of the bell, characteristic of *C. radiatum* and *C. uchidai* (see Figure 1*g*). The polyp of *C. radiatum* possesses filiform tentacles, while the mature polyp of *Cladonema pacifica* is not known (Naumov 1955, 1957, 1960). The morphology of the polyp and adult medusa agrees in all respects with *C. uchidai*, and the hydroid found in the display tanks on the Berkeley campus is almost certainly of the same species (Table 2).

The little that is known of the variation within a single species of hydrozoan suggests that the species of *Cladonema* listed in Table 2 are valid. The differences in morphology between the mature medusae of *C. uchidai* and *C. myersi*, while relatively minor (number of radial canals and mode of branching of the radial canals as they issue from the apex of the bell) can be used to distinguish between hydrozoan species. *C. californicum* was found to have virtually no variation in number of radial canals per individual medusa in scores of specimens examined (J. T. Rees 1979*b*). Vannucci (1960) found little variation in number of radial canals in clones of *Merga tergestina*. I reported a variable number of primary radial canal development in *Proboscidactyla flavicirrata* (J. T. Rees 1979*a*), although such development was rare and considered an irregularity. As the material available to W. J. Rees (1949) apparently included but one mature female medusa of *C. myersi*, only additional collection of *C. myersi* will determine the extent of variability of its radial canal development and thus its systematic relationship to *C. uchidai*.

The field habitat of *Cladonema uchidai* in the San Francisco Bay area is unknown. Three years of collections of hydromedusae in the Bodega Harbor area of the central California coast revealed the polyp and medusa of *C. californicum*, but not *C. uchidai* (J. T. Rees 1975, 1979*b*). It is strongly suspected that *C. uchidai* is present in San Francisco Bay, being introduced into the tanks of the Berkeley campus with display material from the bay. *C. radiatum* has been reported from a variety of locations in East Asia including North Honshu, Hokkaido, and the Kurile Islands in Japan (Uchida 1940) and the Yellow Sea in China (Jinbiao 1979). *C. uchidai* is quite possibly synonymous with specimens found in these locations, as well as with *C. pacifica* described by Naumov (1955) from the environs of Vladivostok, the mature polyp stage of which has not been described. *C. uchidai*, therefore, may have a wide distribution in

TABLE 2

COMPARISON OF THE MORPHOLOGY AND KNOWN DISTRIBUTION OF SPECIES OF *Cladonema*

| SPECIES | POLYP FILIFORM TENTACLES | ADULT MEDUSA | | | DISTRIBUTION |
|---|---|---|---|---|---|
| | | NUMBER OF RADIAL CANALS | BRANCHING OF RADIAL CANALS | BRANCHING OF REGULAR TENTACLES | |
| *C. californicum* Hyman, 1947 | Present | Usually 9 | No | Bifurcated | West Coast of North America: Monterey, California, to British Columbia |
| *C. myersi* W. J. Rees, 1949 | Absent | 5–7 | No (?) | Much branched | La Jolla, California |
| *C. pacifica* Naumov, 1955 | Not known | 9 | No | Much branched | USSR: Sakhalin, Vladivostok |
| *C. radiatum* Dujardin, 1843 | Present | 7–11 | Yes | Much branched | Atlantic: West Coast of Europe, Bermuda, Bahamas; Mediterranean<br>East Asia: Yellow Sea, China; Hokkaido, Kurile Islands, Japan* |
| *C. uchidai* Hirai, 1958 | Absent | 8–9 | Yes | Much branched | Japan: North Honshu |

* East Asia records for *C. radiatum* are possibly synonymous with *C. uchidai*.

East Asia. San Francisco Bay has a history of species introductions from Australasia (Carlton 1975), and the San Francisco Bay habitat is a suitable environment for the *Cladonema* polyp and medusa. San Francisco and Oakland are major ports of entry from East Asia, and introductions from that region might be expected; therefore, *Cladonema* polyps and medusae found in San Francisco Bay should be suspected as being an introduction.

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